How Low Can We Go?
How Close Can We Get?

Summary of Water-Energy Research for the California Energy Commission

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Acknowledgements

Code Changes and Implications of Residential Low Flow Hot Water Fixtures

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Background

1. Plumbing fixture flow rates, flush volumes and appliance fill volumes have been reduced every decade since the 1950s.
2. Pipe sizing rules have not been revisited since written down in the 1940s.
3. The median square footage of a house is roughly 1.5 times larger than it was in 1970.

Result:

1. it takes much longer than it used to for hot water to arrive.
2. More energy is lost when the pipes cool down.
3. Dissatisfied occupants
4. Potentially unsafe conditions in the piping network

Relevant Codes and Standards

Appliance and Equipment Standards

Health Codes

Plumbing Codes

Energy Codes and Standards

Green Codes and Standards

Design Guides

Standards of Practice

Anything else?

Unintended consequences due to separate development!

Agreement Goals

1. Develop code change recommendations based on comprehensive assessment of technical, economic, and market feasibility improvement strategies that can significantly increase hot water distribution system efficiency in new construction and existing buildings;
2. Characterize the impact of low flow fixtures on distribution system performance and determine the theoretical lowest flow possible for hot water fixtures.

Ratepayer Benefits

This Agreement could result in the ratepayer benefits of annual savings of 4.6 million therms of natural gas, 7 million gallons of water, and $4.6 million of utility bill reduction in 2030. The estimated savings and associated emission reductions are 24,500 metric tons of CO_2e and 5,600 kg of NO_x. These savings are projected from 2020 to 2030 based on improving Title 24 Building Standards on DHW systems in low-rise residential homes.

This is a low estimate of the potential savings.

Agreement Objectives

1. Identify system design and control strategies that can significantly increase the energy and water efficiency of hot water distribution systems in new construction and existing buildings.
2. Investigate the technical feasibility of distribution system improvement strategies that integrate both minimized pipe volume and low flow rates by applying them to a range of building designs, and assess the impact of building architecture designs on pipe volume.
3. Develop a model to characterize transient hot water delivery processes in different types of pipes and use this model to further develop a performance analysis tool to assess hot water distribution system performance affected by piping layout, draw schedule, flow rate, and occupant behaviors in waiting for hot water.

Agreement Objectives – continued

4. Evaluate the performance, cost, and cost effectiveness of the improvement strategies. Assess market barriers to the adoption of each improvement strategy.
5. Use the transient hot water delivery model and distribution system design examples to characterize hot water delivery with low flow rates, identify performance factors that are sensitive to low flow rates, and assess the lowest acceptable flow rates that provide hot water usage performance requirements without degrading distribution efficiency.

Agreement Objectives – continued

6. Evaluate the performance of distribution systems using low flow fixtures and compared to systems without using low flow fixtures. Investigate other performance issues, e.g. health and safety issues, biofilm and pathogen growth related to the use of low flow fixtures. Examine the impacts on the supply and drain plumbing in the building and in the water supply and wastewater treatment systems.
7. Develop recommendations to improve regulations, codes and standards based on the integrated assessment of distribution system improvement strategies and the utilization of low flow – high performance fixtures.

Variables to Account For:

- Time-to-Tap
- Volume-until-Hot
- Flow rates and fill volumes of plumbing fixtures and appliances
- Patterns of hot water use, now and over time
- Longevity of the hot water system infrastructure
- Potential for pathogen growth and harm
- Anything else?

So What Can We Do?

1. Decide how long we want people to wait for hot water to arrive.
2. Account for the fact that it takes approximately twice as much water as in in the pipe for hot water to arrive at the other end of the pipe.
3. Select pipe diameters based on the pressure drop due to flow rates. Minimize the number of fittings, particularly 90^o elbows.
4. Work backwards to get the distance from the source of hot water to the uses.
5. Cluster the uses of hot water close to each other and to the source of hot water that serves them. There can be more than one cluster in each dwelling.
6. Locate these clusters such that the wet rooms are surrounded by dry rooms.

So What Can We Do? (continued)

Result:

- >75% reduction in hot water distribution length (similar savings in cold water piping, drain lines and vent stacks
- >75% reduction in hot water distribution pipe volume
- Time-to-tap less than 15 seconds at all fixtures and appliances
- Volume-until-hot less than 2 cups
- Reduced construction costs ($2-3,000 for plumbing, $5-10,000 for all mechanical)

So What Can We Do? (continued)

- Some examples:

- 4 Wet Rooms: 2 bathrooms, 1 kitchen, 1 laundry
- 8 Wet Rooms: 5 bathrooms, 1 kitchen, 1 laundry, 1 wet bar

- Compact wet room core
- Compact mechanical room core

- Drop ceilings, closets with removable panels, serviceable mechanical equipment, including filters without the need for a ladder

When you have been asked to “make it so!”

- Options for existing buildings where it is not possible to optimize the layout of the wet rooms

Preliminary Conclusions

1. Design and build dwellings with floor plans that allow for efficient mechanical infrastructure
2. Reduce the UA of the hot water distribution system (reduce the length, optimize the diameter, insulate like crazy)
3. Reduce hot water system complexity
4. Reduce the amount of time the hot water distribution system spends in the pathogen high growth temperature zone
5. Utilize waste energy where practical
6. Select efficient water heaters that match the system parameters

Questions?